



地球研・地下環境プロジェクト 全体会議

(FR5:Full Research 5年目)

幕張:2010年5月26日

10:00-10:30	全体説明(谷口)
10:30-10:40	社会経済(金子)
10:40-10:50	都市地理(吉越)
10:50-11:00	水(嶋田)
11:00-11:10	重力(西島)
11:10-11:20	物質(小野寺)
11:20-12:00	Model WG (安元)
12:00-13:00	昼食
13:00-13:10	熱(山野)
13:10-13:40	Data Base(豊田)
13:40-14:10	出版
14:10-15:00	データ公開・今年度会議予定・ 購入機器扱い・MOU・NL

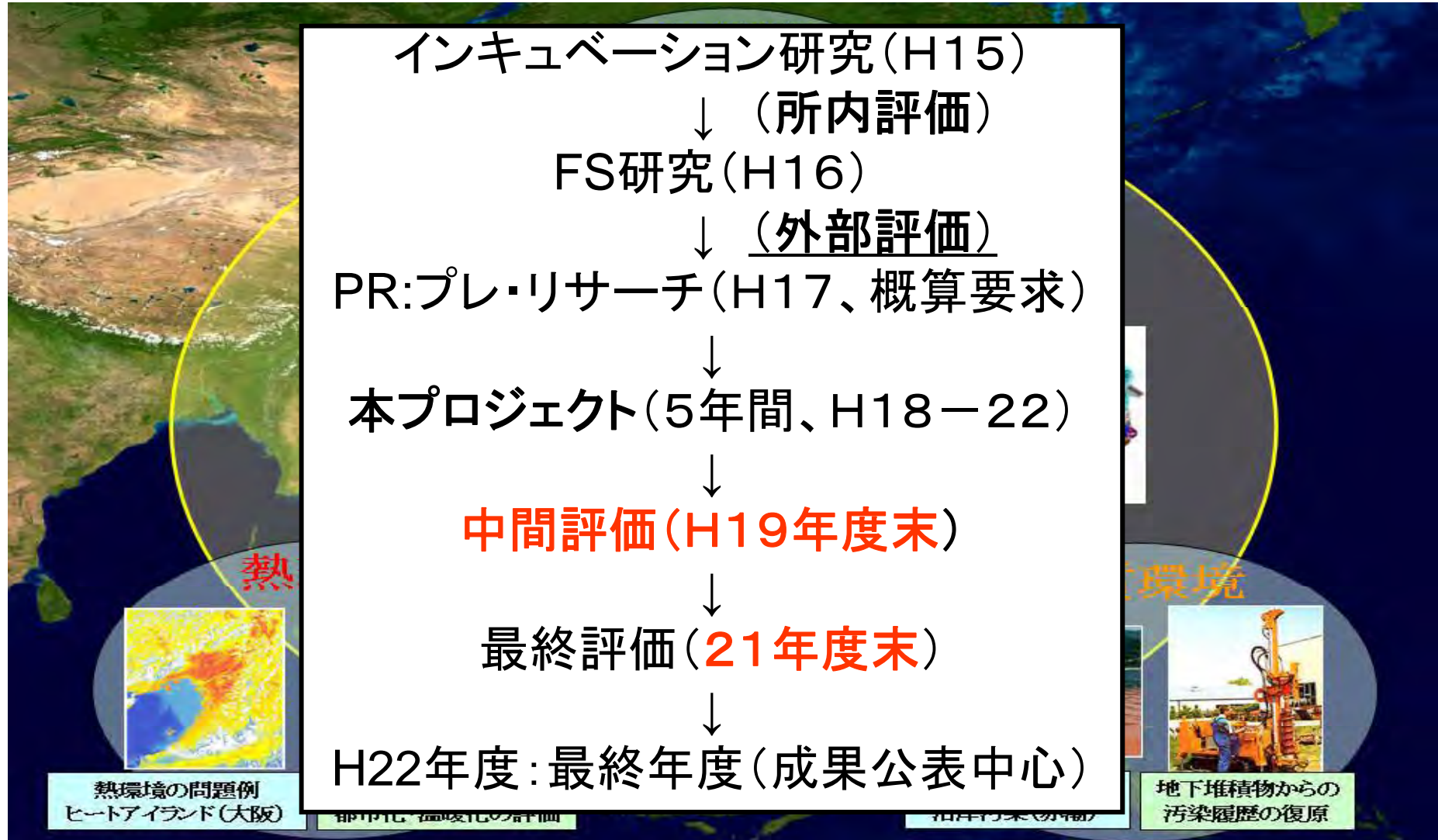


地球研プロジェクト・C05「**地下環境プロ**」(H18-22)

「**都市の地下環境に残る人間活動の影響**」

Human Impacts on Urban Subsurface Environment

<http://www.chikyu.ac.jp/USE/>



最終評価 Penultimate year FR evaluation

March 31, 2010

Title of the Project	Human Impacts on Urban Subsurface Environments
Project Leader	TANIGUCHI Makoto
<p>General advice and comments of PEC: PEC is impressed with the achievements of this project. Research in two areas could strengthen it even further: quantification of total groundwater extraction rates, and investigation of the relation between urban groundwater supplies and the larger watershed. In the final year, attention should now turn to the dissemination of project results, especially to the <u>public officials</u> who could incorporate them into <u>urban environmental policy</u>.</p> <p>The Project Evaluation Committee members made the following comments:</p> <ul style="list-style-type: none">● This project is certainly the first big research program treating groundwater of big cities and has produced very valuable outputs. This output will become even more valuable if, in the final year of research, project members can discuss the potential contribution of <u>upstream precipitation to urban groundwater supplies</u>.● Excellent in all criteria.● This project has a significant potential social impact. <u>Effective ways to utilize the collected data</u> should be considered.● This project has progressed well and has revealed the real conditions of urban subsurface environment in major Asian cities, although <u>“human” aspects have been less involved</u>. Judging by the recommended criteria, this project is excellent, particularly in its social contribution, because the findings are very relevant to environmental policy. In the final year, the findings of this project, including <u>DPSR causal relations</u>, should be discussed by many groups so that more <u>generalized use</u> of them can be made.	

- Since the team has shown an excellent achievement so far, in the coming fiscal year, it is expected to develop the mechanism for applying the results to practical aspects such as management of groundwater issues by local authorities.
- A well-organized study with original insights, although the mode of producing their findings in a single dimensional “ranking” of the target cities is rather conventional. The sophisticated technological methods in attaining a certain precision in such studies ought to be explained more clearly when explanations are given to the public. This point seems important for the project to enhance their influence upon policy makers and other stakeholders.
- This was a very competent and informative presentation. I have no detailed comments.
- Integrative/Interdisciplinary: Very well done in terms of statistics and hard data. Very competitive. Where is the humanity side? I learned a lot. So what? What is your suggestion to explain the quality of life? I do not feel the human lives in these cities. It is a good chance to demonstrate the issue of wisdom of the indigenous people in terms of environmental degradation. This is going to be a benefit for the future. In this aspect, is there any explanation related with colonial expansion especially concerning Taipei and Seoul as well as Jakarta in terms of microhistory of urban development? Innovative/Academic: Excellent progress.
International: more than excellent.
Social contribution: excellent. If we consider this issue of social contribution done by this research, we should focus on legal problems related with groundwater resources. Any suggestion with this?

- I am deeply impressed by the high quality research of this project. There are a number of interesting findings, such as: the increasing heat storage of 2-3 times in the subsurface in past 100 years (this is not well-known in the existing literature); the acceleration of GW circulation more than 10 times, and others.
In addition, the project has used multiple sources of high quality information and multi disciplinary data, such as satellite data (GRACE), reanalysis data and models, social data, etc.
In general, the research quality meet the criteria of RIHN's project, the three “I” (integration, innovative and international).
But careful analysis on the major driving forces of such change is recommended.
- A fascinating topic with very interesting results. Well presented and clearly thought out. Excellent work and useful for the local communities.
- - 1) The five points in the evaluation are well satisfied.
 - 2) The ground water budget is well estimated. One important component is missing: the extraction rate. This must be added to complete the budget.

IKAWA-SMITH, Fumiko

Chair, Project Evaluation Committee

Three subjects

Water → land subsidence
 Material → contamination
 Heat → thermal storage

Two G of indices

A: Changing Society & Environment

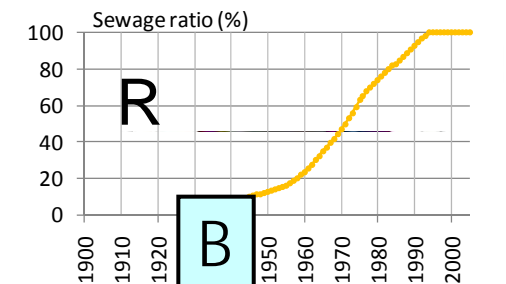
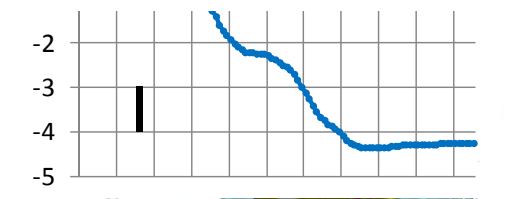
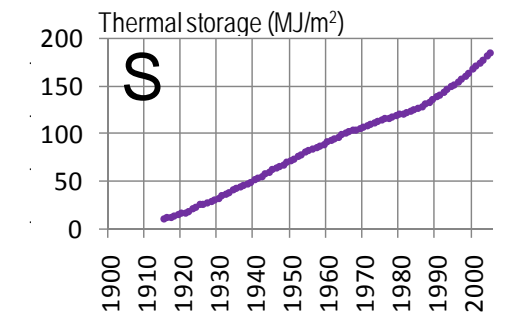
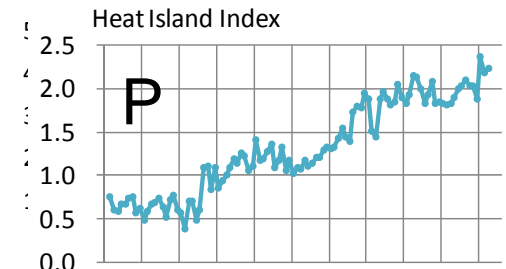
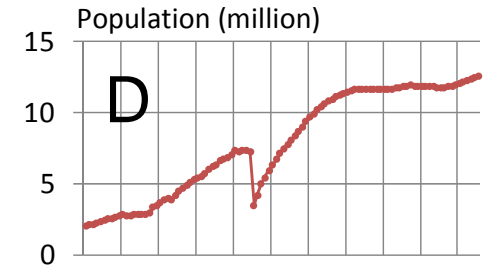
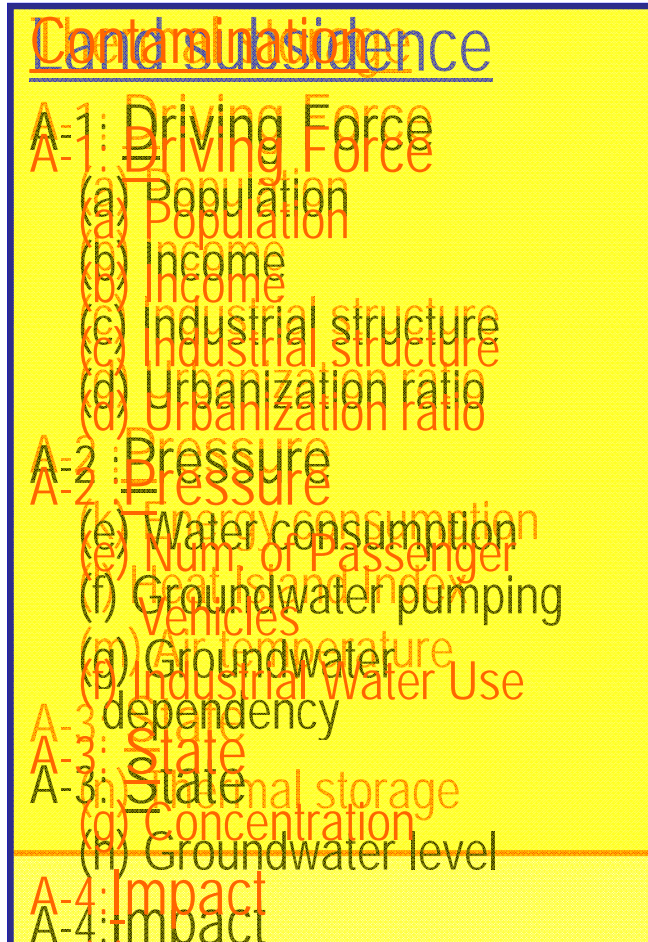
B: Natural Capacity

B-1: Hydro-climate

- (a) Storage
- (b) Recharge
- (c) Turnover time

B-2: Geology-geomorphology

- (d) redox
- (e) gradient/permeability
- (f) thermal gradient



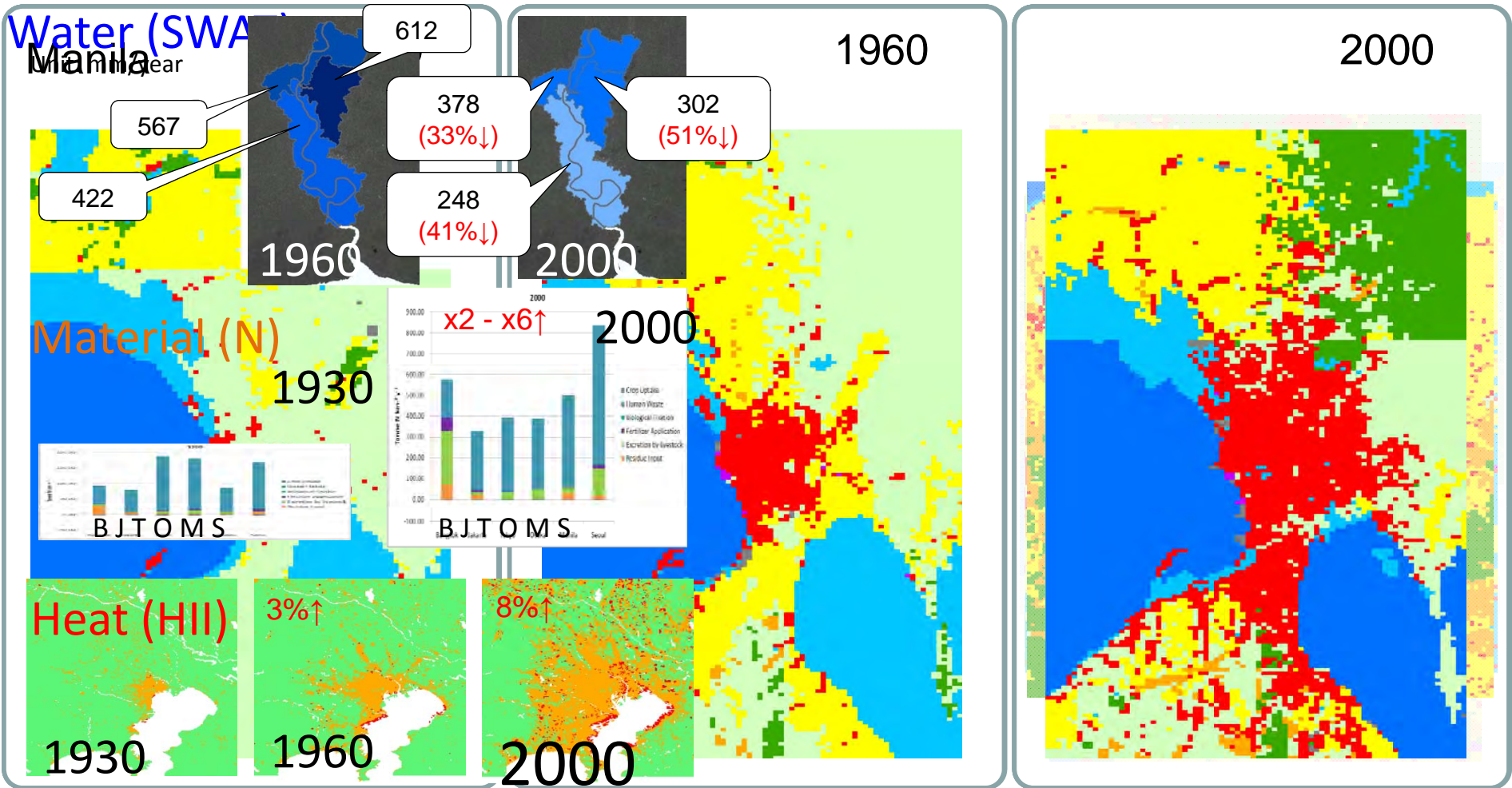
Land use/cover changes

(0.5 km grid, 7 cities, 3 ages)

A

Water → recharge
 Material → contamination
 Heat → heat storage

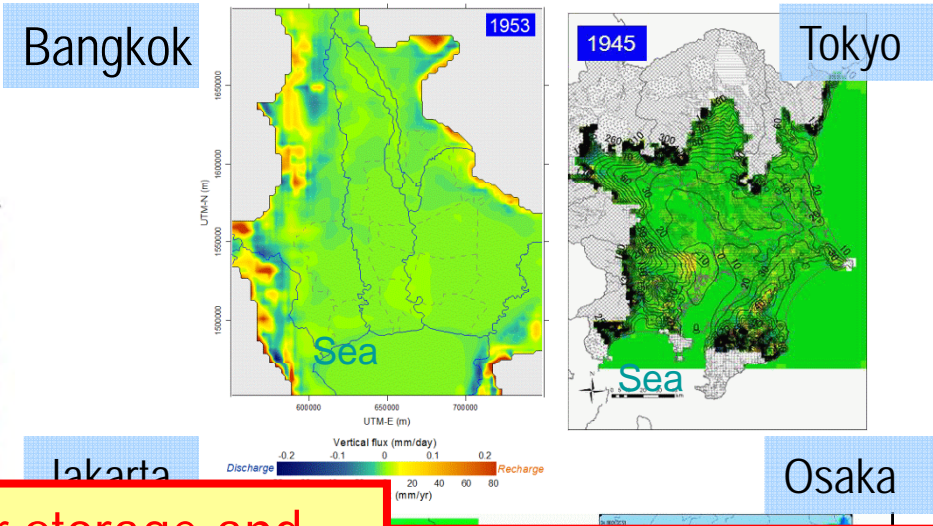
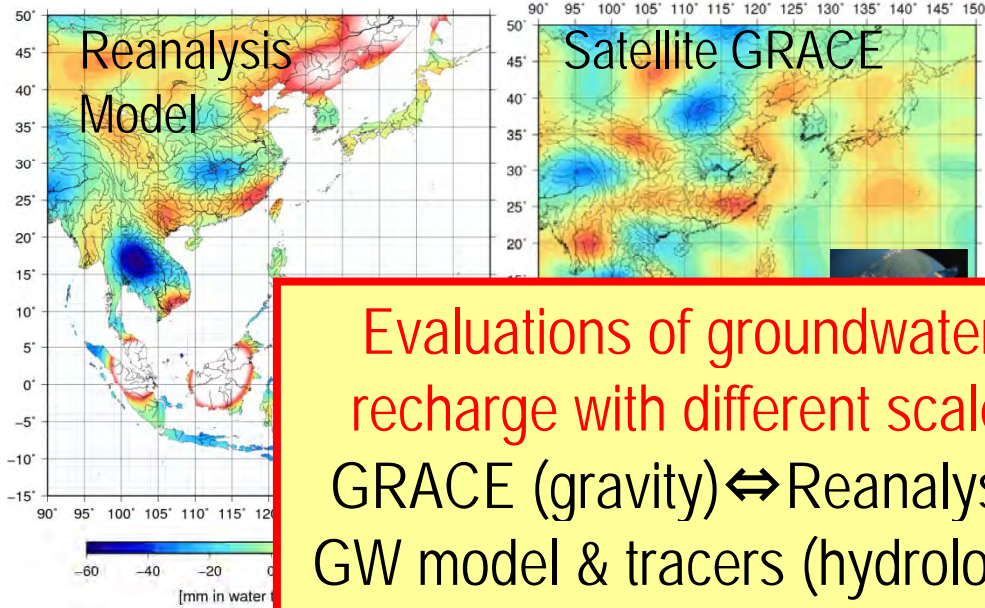
- Forest
- Grassland
- Rice
- Agriculture
- Industry
- Urban
- Wetland
- Others
- Ocean



Water

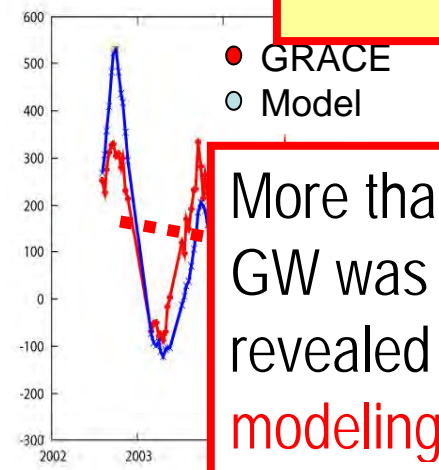
Storage change (2002-2008)

A

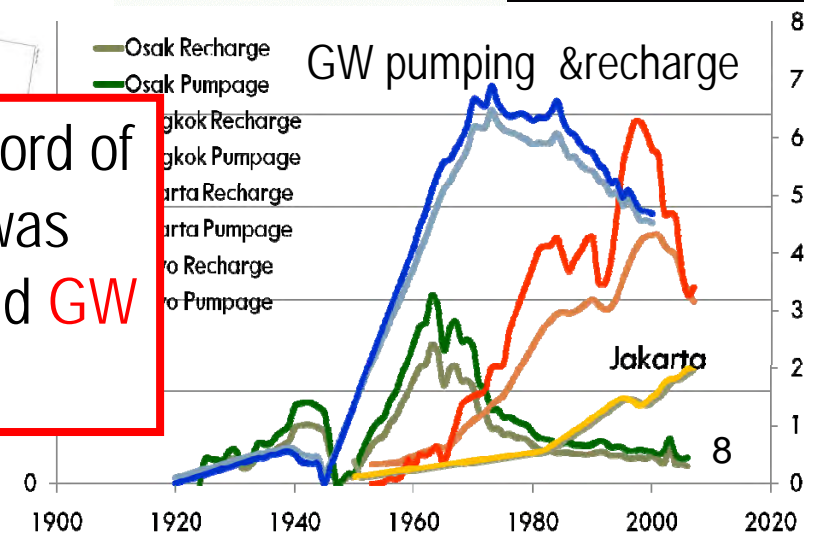
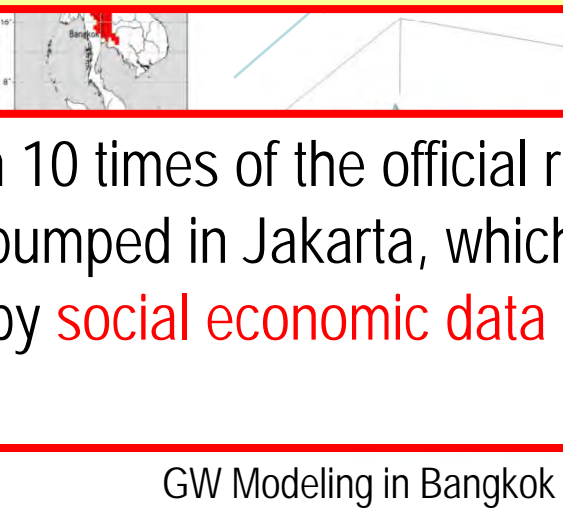


Evaluations of groundwater storage and recharge with different scales & methods
 GRACE (gravity) ↔ Reanalysis (climate) ↔
 GW model & tracers (hydrology) ↔ Statistic Data (social economy)

Groundwater recharge
 in suburbs after regulation
 of pumping



More than 10 times of the official record of GW was pumped in Jakarta, which was revealed by social economic data and GW modeling.

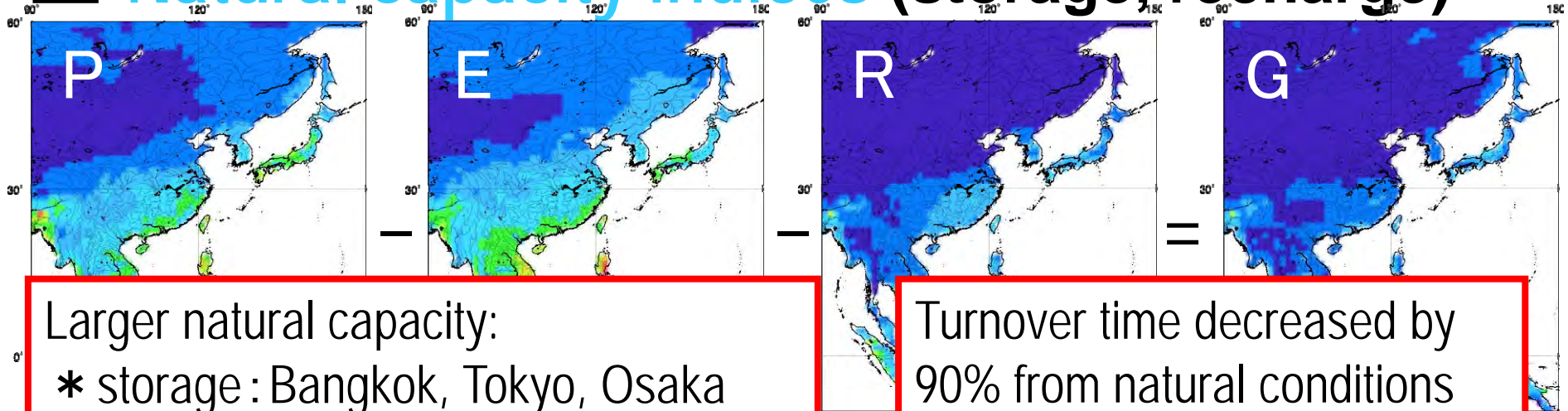


Land Water Change in Chao Phraya

GW Modeling in Bangkok

1900 1920 1940 1960 1980 2000 2020

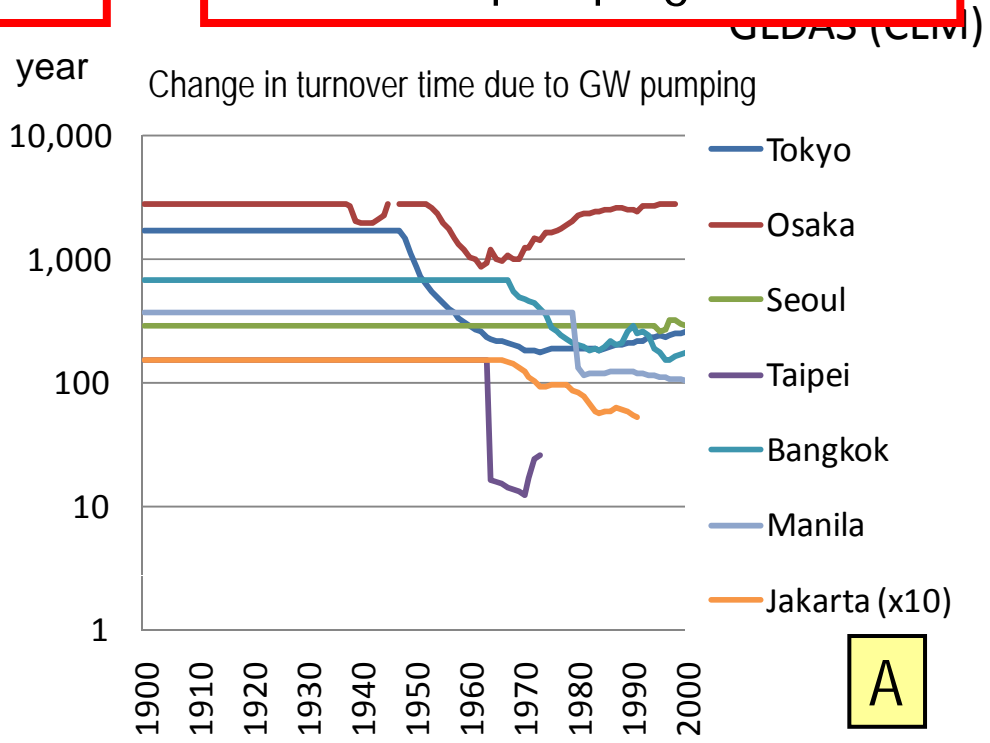
B Natural capacity indices (storage, recharge)



Larger natural capacity:
 * storage : Bangkok, Tokyo, Osaka
 * recharge : Taipei, Manila

Turnover time decreased by 90% from natural conditions due to GW pumping

	thickness	area	Storage	Recharge rate	Turnover time
	m	km ²	M ton	mm/year	Year
Tokyo	600	622	75	346	1,732
Osaka	1,200	222	53	429	2,799
Seoul	100	605	12	343	291
Taipei	100	272	5	644	155
Bangkok	300	1,569	94	449	669
Manila	300	632	38	819	366
Jakarta	100	740	15	640	155



$\tau = S/Q$
 τ : Turnover time (year)
 S: Storage capacity(m³)
 Q: Recharge (m³/year)

A

Accumulation

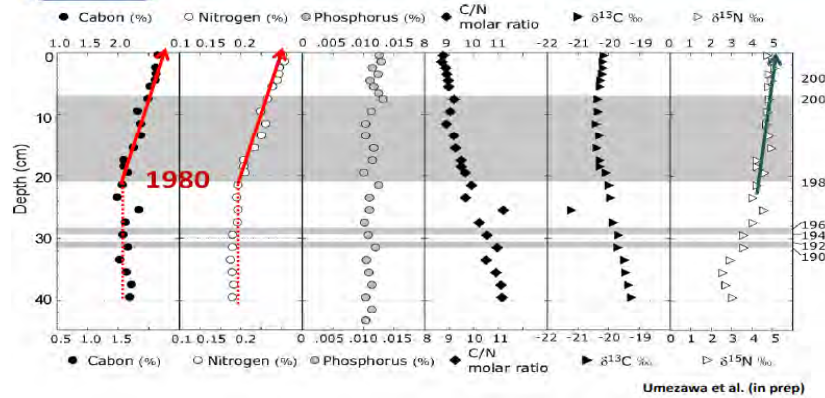


Material



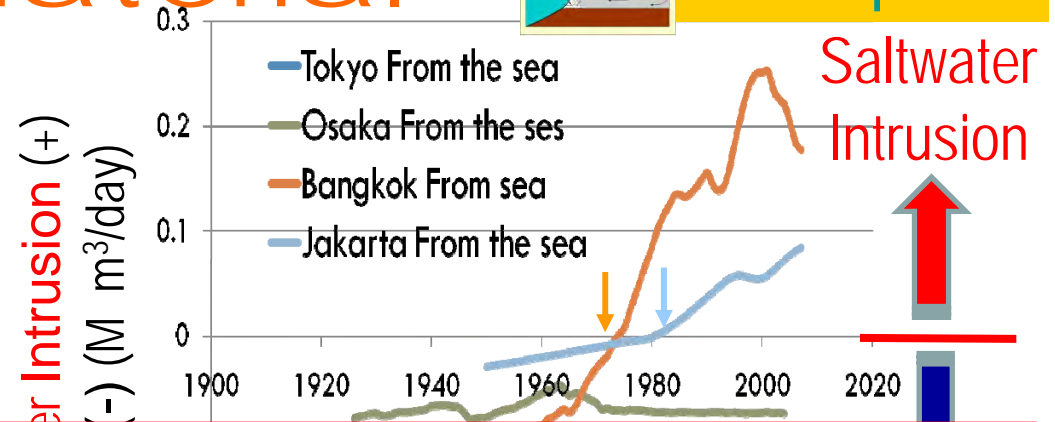
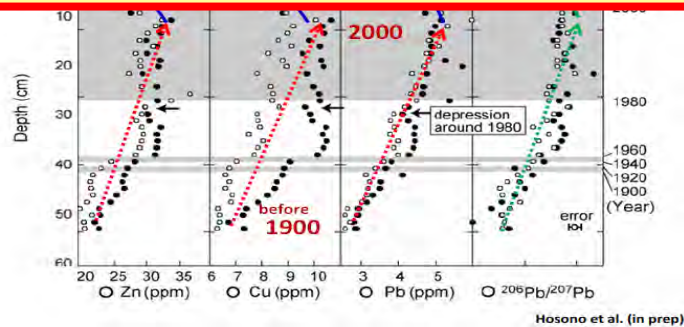
Transport

- Organic Matter in Osaka Bay
- Organic Matter in Jakarta Bay
- Organic Matter in Manila Bay

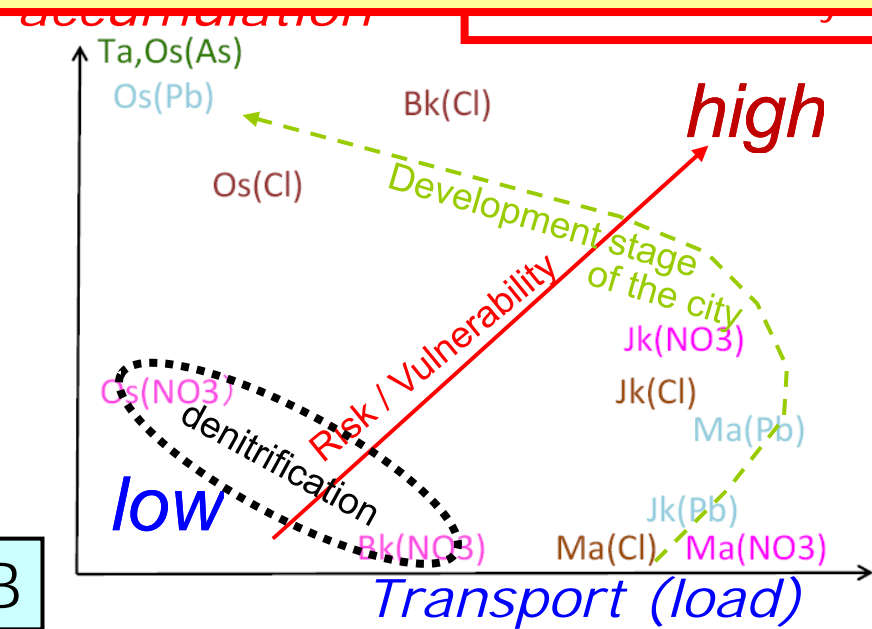


- Heavy Metals in Osaka Bay

Reconstructions of contaminant history from sediments and social economic data



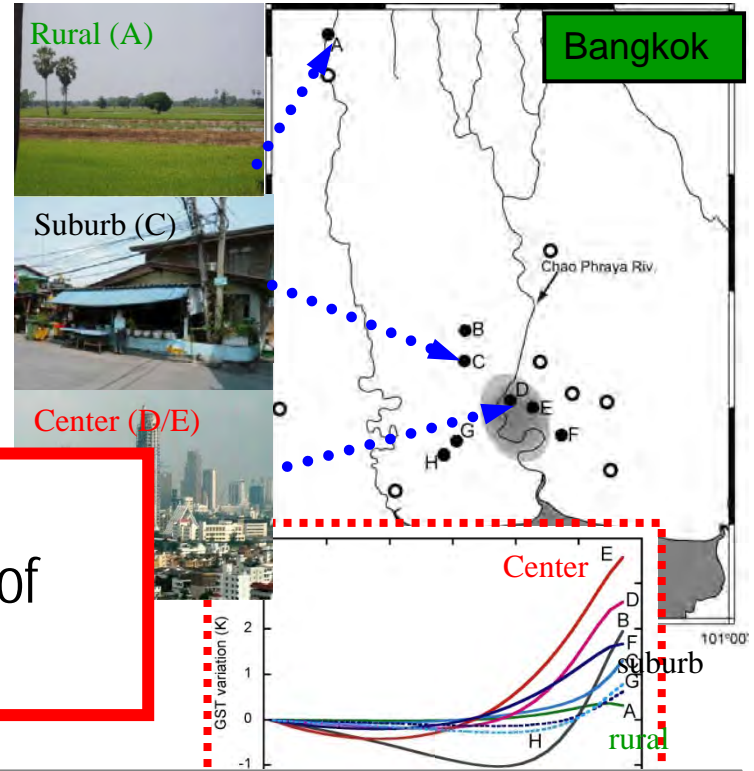
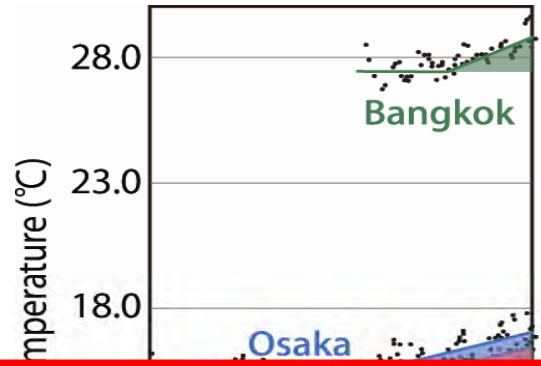
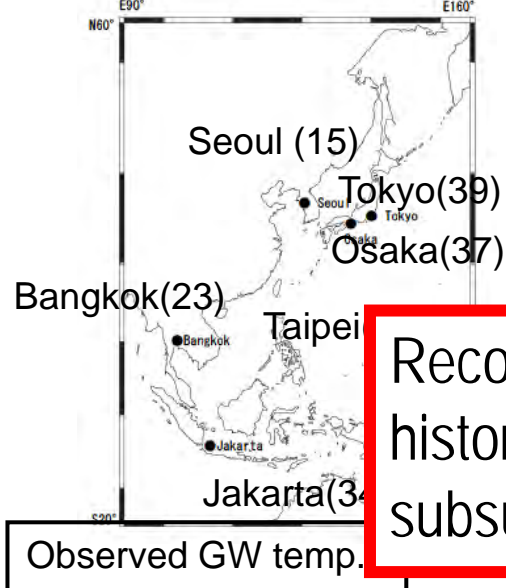
Comparison of risk / vulnerability from "accumulation" and "transport" points of view



A B

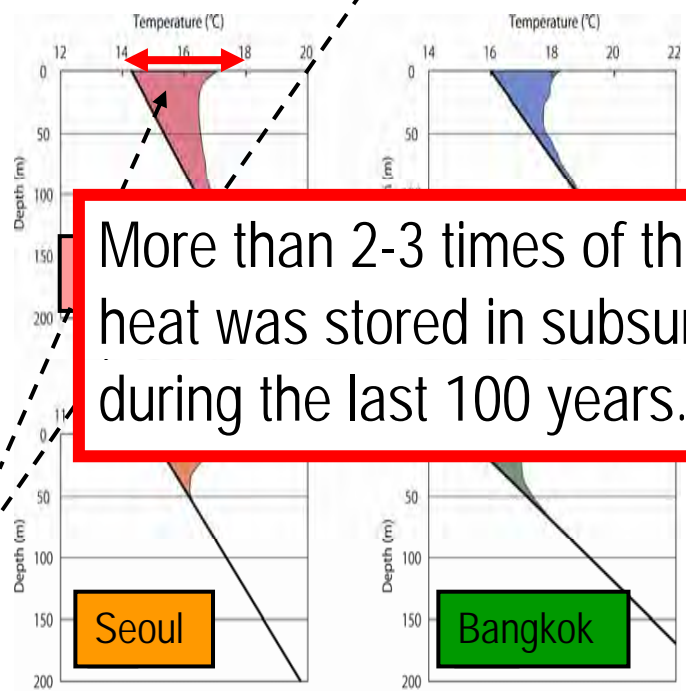
Heat

A

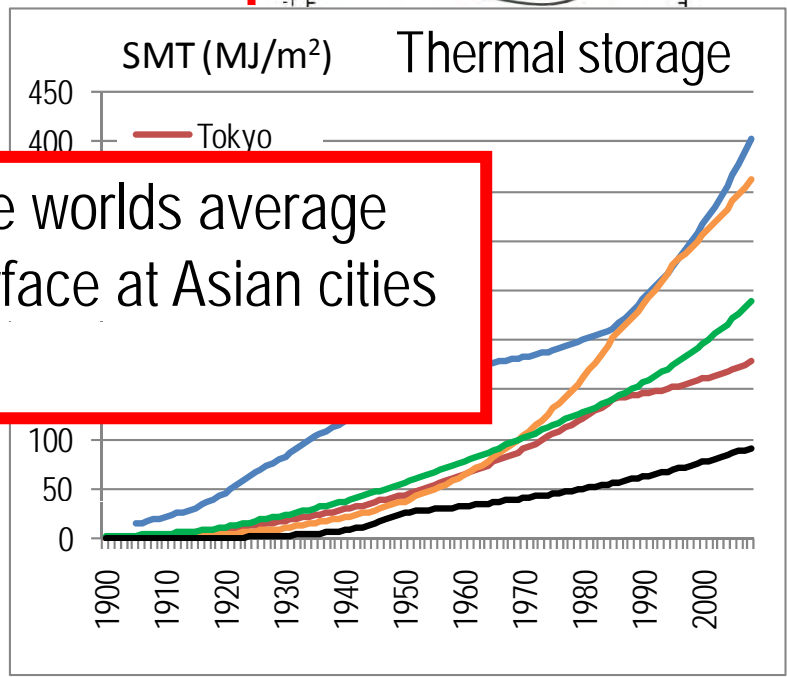


Reconstructions of urbanization history have been made by uses of subsurface temperature

Increased thermal storage depends on magnitude and timing of surface warming → index of urbanization



More than 2-3 times of the worlds average heat was stored in subsurface at Asian cities during the last 100 years.



Integrated model with (A, B cities)

Stage model with DPSIR framework (Development stage of the city)

Water demand transition (share of industrial water demand)



Water supply transition (dependency on groundwater)



Policy transition (land subsidence)



1916 1961 1975

1st stage:

2nd stage:

3rd stage:

4th stage:

5th stage:

Beginning of urbanization

Increase of Industrial water demand

Recognition of Land Subsidence

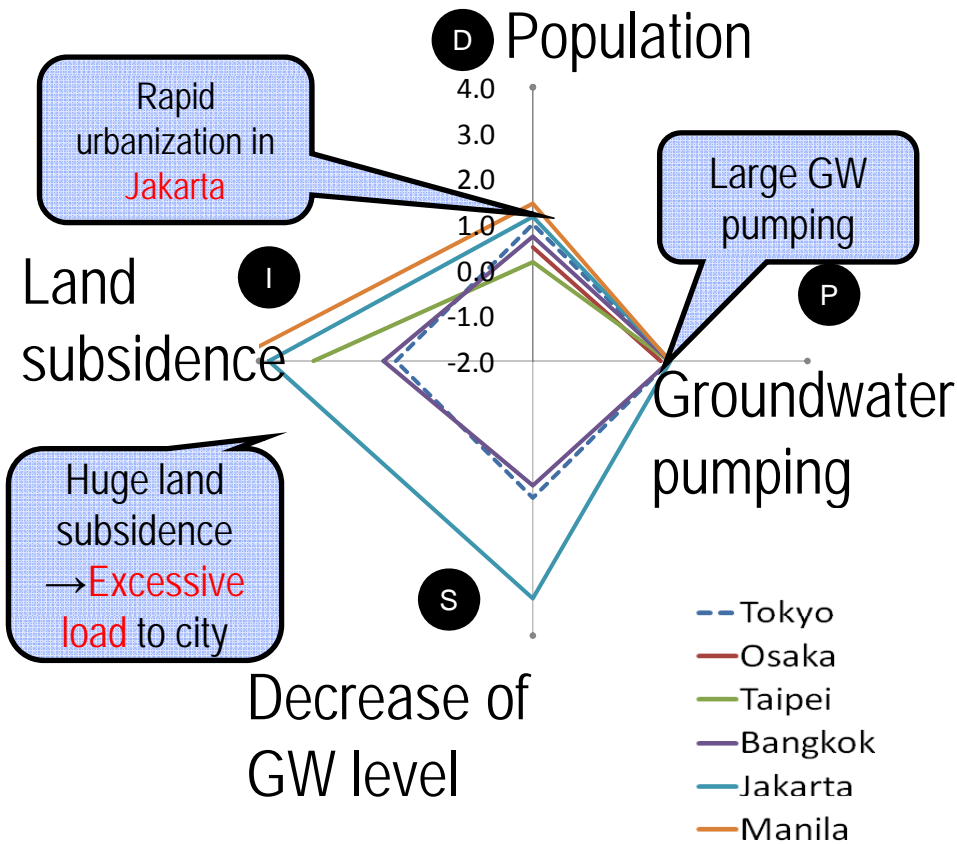
Regulation and Effective measures

Settlement

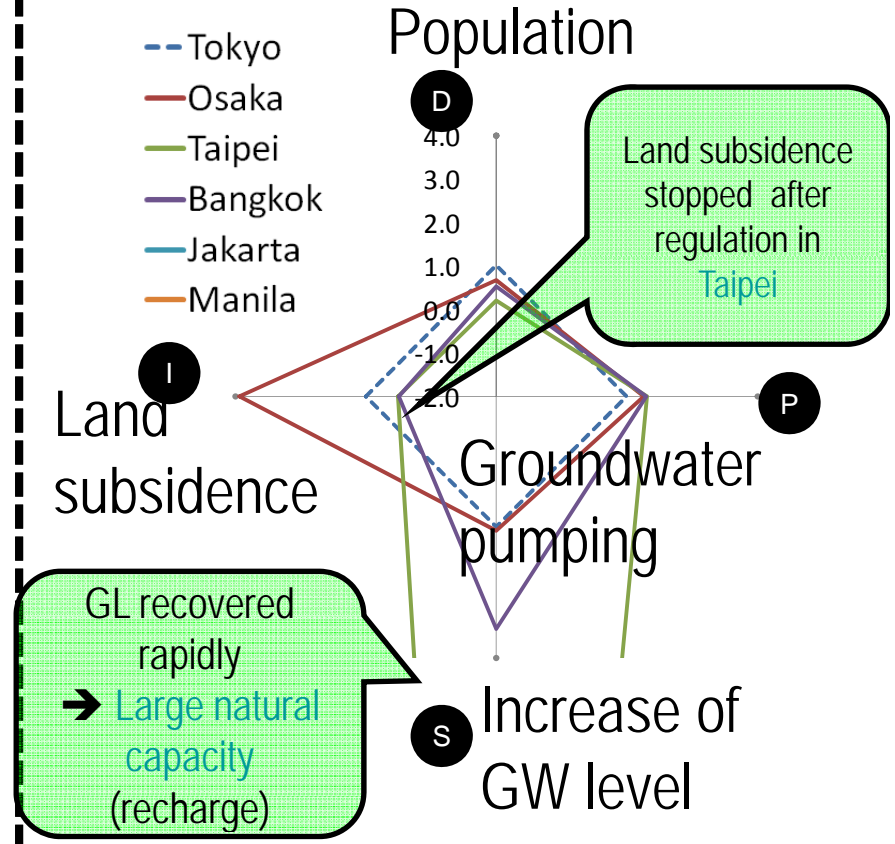
Tokyo	1915/16	1922/23	1959/60	1974/75
Osaka	1917/18		1957/58	1979/80
Taipei	1915/16		1955/56	1978/79 1985/86
Bangkok			1950/51	1970/71 1996/97
Jakarta				1973/74 1993/94
Manila				2001/02

Groundwater charge system was introduced just after the recognition of land subsidence. (short 3rd stage means followers benefit)

3rd stage Recognition



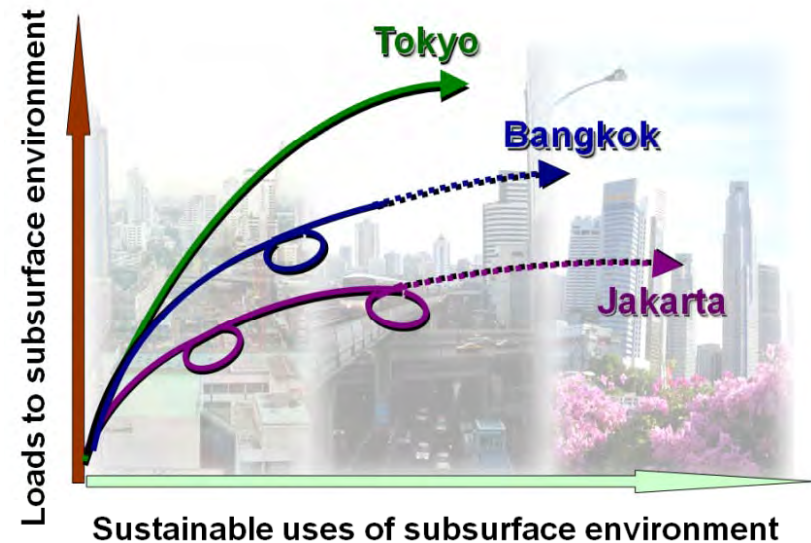
4th stage: Regulation



Development pattern	City
A: Following Tokyo	(Tokyo), Osaka
B: Excessive Development	Jakarta
C: Followers benefit	Bangkok, (Manila)
D: Natural Capacity Benefit	Taipei, (Bangkok)

Conclusions

- Integrated study on urban subsurface environments beyond the boundaries, **surface-subsurface** and **land-ocean**, revealed that:



- (1) Repeated subsurface problems occurred due to increase in water demand and urbanization, then **accelerated the GW circulation** (more than 10 times). It also increased the accumulation of material and heat in subsurface,
- (2) The **alternative** resources are important for society, thus groundwater/subsurface environments are key for **adaptation** to the changing society and environment. Subsurface environments can be sustainable with **careful management**, and
- (3) Integral management of subsurface environments are necessary based on **natural capacity** and use of **followers benefit**.

The following are our planned activities for the final year

- (1) Thematic and each study city will form a chapter in **4 book publications** in both Japanese and English. **Two** more **special issues** of peer review journal will be completed by March 2011.
- (2) We will do necessary follow-up field studies in each city **to transfer the evaluated methods** for assessing the subsurface environments, including the monitoring system.
- (3) We plan to assess a variety of possibilities for the cities with similar subsurface problems to **benefit from the experiences** of the earlier-stage cities as well as its own **natural capacity**.
- (4) We will organize an **International Symposium** on **"Groundwater – as a key of adaptation to changing climate and society"** on November 14-16 at Kyoto to show the final outcome of the project to both the public and science communities.

プロジェクトの最終目標

地球環境問題は、その問題が地球全体に影響が及んでいるか、あるいは地球上で普遍的に発生し未来可能性を食いつぶしている環境問題といえる。本プロジェクトの対象は後者に相当する。

現在発生している「地下に潜む地球環境問題」の作用環を明らかにすることで、「未来可能性」を食いつぶしている現状を理解し、(1)地表水-地下水の間の水資源転換、(2)汚染地下環境の放置問題、(3)有効地下環境利用等に対して、未来可能性を提示することで「地球環境問題」の解決に資する。

このプロジェクトでは、地下水・地下環境をより賢明に活用し、共生する統合的考え方・手法を提示することを最終目標とする

認識科学⇒観測・解析 設計科学⇒解析・提示

明らかにになったこと

- 過去100年の地下水・地表水間の水資源転換史
- 揚水により地下水入れ替わり時間が10倍以上短縮。涵養域の変化、浅層地下水による混合
- 陸水モデルのダウンスケールの可能性と限界
- 測地学・気象学・水文学・社会経済学によるクロススケール・クロスチェック
- 汚染の蓄積と輸送による脆弱性・リスク評価
- 地下熱による都市化復元。蓄熱史
- 土地利用
- 指標化「変化する自然・社会指標群」と「自然許容量指標群」による問題の理解と提示
- 関係性「後発の利益享受」と「自然許容量の認識」を基礎にした政策メニュー提示の可能性

最終目標へむけて

(1)地表水-地下水の間の水資源転換

地表水(公水)と地下水(私水)のどちらをどの段階で利用するのが、負荷を(何に?)少なく、より利益を(何に?)もたらすか?

(2)汚染地下環境の放置問題

地下の物質汚染・熱汚染を、このまま放置することは、どのような未来可能性を奪うのか?
⇒Risk/vulnerability mapの精査

(3)有効地下環境利用

これまで別々に捉えられてきた、「地上環境」といわずれ地上にその影響が現れる「地下環境」を統合的に捕らえ、問題に対するalternative/adaptationとして地下環境を捉えることで、どのように有効利用できるのか?

政策提言にむけて

(1) **地下環境は**、温暖化や人間活動の活発化によるグローバル化に対する

(A) (水資源の) **Alternative**

(B) (変化に対する) **Adaptation**

地下環境を、地域の **Resilience** (回復力) として捕らえ、その大きさを評価する。貯留量・涵養量・滞留時間等

⇒ Environmental Policy (RIHN)、コンソーシアム？

UNESCO-国際シンポ (11月14-16日)

(2) **地下水公水化** へ向けての問題点整理⇒

11月26日大阪シンポ (共有資源の悲劇を超えて)

H22年度の各班目標

- **社会経済**

- (1) 汚染(鉛・窒素)と地下熱のステージモデル完成と提言シナリオ
- (2) 統合指標(全項目)と他班データの統合

- **物質:**

- (1) 物質負荷(供給(原単位)と蓄積)の評価。
- (2) Vulnerability / risk 表の精査

- **重力:**

- (1) GRACEのダウンスケール。SWATと比較(バンコク)
- (2) 現場重力測定による水収支評価改善の精度。

- **都市地理:**

- (1) GIS解析(7都市3時代土地利用変化の共通性・相違)
- (2) 法制度・宗教と地下環境との関係の類型化

- **地下熱:**

- (1) 蓄熱量100年変化の完成。地下水位低下の影響評価
- (3) 都市気候・土地利用変化との関連性の明確化。

- **地下水:**

- (1) CFC, Krの適用精度・適用限界の明確化。
- (2) 表流水・地下水間の水資源転換の影響評価のシナリオ。

統合(1) GIS・DB・公開

(1) 土地利用変化GIS(7都市3時代)

7都市・3時代区分(1930-1970-2000)・500mメッシュ**完成(3月)**
→**有効利用**

水班:地下水涵養量の7都市・3時代変化 (安元)

熱班:土地利用改変による地下熱変化 (濱元)

物質:汚染源の変化と地下水汚染の拡大 (清水)

(2) Database

生データの提供依頼(3月末まで)(班長収集→PLへ)

図をHP上に掲載(Google上)→評価委員会で説明

データの公開は論文掲載まで待ち、CR2後にはすべて公開の方向

(3) 公開(図:一般公開、データ:登録メンバー制)

Google上に**KML**データとしておき、成果の図などを終了時に公開。

CR2(2013年3月)にはデータも公開

統合(2) Model

(1) 7都市比較モデル

GISの3時代区分に合わせて1930-1960-2000を中心にした10年の平均を求め、都市毎・時代毎の比較を行う

降水量、蒸発量、河川流出量、揚水量

→貯留量変化、地下水涵養量

(2) 4都市流域詳細モデル→都市により担当者

すべての都市を対象とはせず(東京(愛知)、大阪(中屋・安元)、バンコク(山中)、ジャカルタ(利部)。MODFLOWで統一。最低限の共通比較項目を決定。

(3) SWAT

大阪、バンコク

統合(3) 汚染(窒素・重金属) 社会経済G+物質G

統合(4) 法制度・宗教 都市地理G+事務局

22年度project関連会議

- (1) EGU 5月2-6日 ウィーン
- (2) 地球惑星合同大会 2010年5月26日**
プロジェクト全体会議 (半日・懇親会)
- (3) 日本地下水学会 慶応大学
5月29日
- (4) World Water Week 2010年9月 6-10日 スtockホルム
- (5) UNESCO-IHP 国際シンポ 2010年11月14-16日**
Groundwater as a key of adaptation to changing climate and society
- (6) 地球研プロジェクト報告会(2008年12月8-10日)
班長(あるいは代理)に参加要請
- (7) AGU 2010年12月12-17日
- (8) 地下プロ全体会議(最終) 12月22-24日**
- (9) 班長会議2011年2月上旬
- (10) 外部評価 2011年2月17・18日

出版

(1) STOTEN (Elsevier)

(2) From Headwater to the ocean (CRC press)

(3) IAHS publication

(3) アジアの地下環境(学報社)

論文: 査読つき111編 他68編, 発表288件

最終年度出版

*Springer “Groundwater & subsurface environment in Asia

*Springer “Dilemma of Boundaries”

*古今書院「アジアの都市と水環境」

*学術写真集

*CD まとめ集

* CR2まで: Springer(都市別), アトラス教科書